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(54) ELECTRIC FUEL CONTROL CLOSED LOOP AIRCRAFT FUEL SYSTEM

FLUGZEUGKRAFTSTOFFSYSTEM MIT GESCHLOSSENEM REGELKREIS FÜR ELEKTRISCHE KRAFTSTOFFREGELUNG

SYSTÈME DE CARBURANT D'AÉRONEF À BOUCLE FERMÉE ÉLECTRIQUE DE COMMANDE DE CARBURANT

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Description

BACKGROUND

1. Field

[0001] The present disclosure relates to fuel control, and more particularly to electric fuel control for aircraft.

2. Description of Related Art

[0002] Traditional aircraft fuel architecture includes a boost pump and a separate, positive displacement pump within a fuel control. These supply fuel to the fuel nozzles for combustion in the combustor. The pumping elements provide the pressure while the valving within the fuel control throttles the flow for proper scheduling to the nozzles. Separate control units are required for pump motor control and engine control.

[0003] The conventional techniques have been considered satisfactory for their intended purpose. However, there is an ever present need for improved systems and methods for fuel control for aircraft. This disclosure provides a solution for this need. US2016/138473A1, US5406784A and US2018/163636A1 relate to fuel control systems.

SUMMARY

[0004] A fuel control system as defined in claim 1 is provided.

[0005] The engine controller can be a full authority digital engine control (FADEC). The controller can be combined with an engine controller.

[0006] The sensor system of the at least one fuel nozzle can include a pressure sensor on an inlet portion of the respective fuel nozzle and can be configured to produce an input signal indicative of nozzle inlet pressure from the fuel line. The sensor system of the at least one fuel nozzle can include a temperature sensor operatively connected to the respective nozzle to produce an input signal indicative of nozzle inlet and/or outlet temperature. The sensor system of the at least one fuel nozzle can include a flow sensor operatively connected to the respective nozzle to produce an input signal indicative of nozzle fuel flow volume. Each fuel nozzle in the plurality of fuel nozzles can include a respective sensor system operatively connected to provide input to the controller.

[0007] An engine heat exchanger can be operatively connected to the fuel line for heat exchange with fuel passing through the fuel line. The first and second electric motor controlled fuel pumps can be the only pumps in the fuel line. There need be no valves in the main line from the first and second electric motor controlled fuel pumps to the plurality of fuel nozzles. There need be no bypass line bypassing flow through the fuel line.

[0008] A method of controlling fuel flow in a gas turbine engine as defined in claim 12 is also provided.

[0009] These and other features of the systems and methods of the subject disclosure will become more readily apparent to those skilled in the art from the following detailed description of the preferred embodiments taken in conjunction with the drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] So that those skilled in the art to which the subject disclosure appertains will readily understand how to make and use the devices and methods of the subject disclosure without undue experimentation, preferred embodiments thereof will be described in detail herein below with reference to certain figures, wherein:

Fig. 1 is a schematic view of an embodiment of a system constructed in accordance with the present disclosure, showing the fuel control system connecting between an aircraft fuel tank and a gas turbine engine aboard the aircraft; and

Fig. 2 is a is a schematic view of the fuel control system of Fig. 1, showing the dual electric motor controlled fuel pumps.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0011] Reference will now be made to the drawings wherein like reference numerals identify similar structural features or aspects of the subject disclosure. For purposes of explanation and illustration, and not limitation, a partial view of an embodiment of a system in accordance with the disclosure is shown in Fig. 1 and is designated generally by reference character 100. Other embodiments of systems in accordance with the disclosure, or aspects thereof, are provided in Figs. 2, as will be described. The systems and methods described herein can be used for fuel control in aircraft, such as in more-electric aircraft.

[0012] A gas turbine engine, e.g. used for propulsion on an aircraft, includes a compressor 12, which feeds compressed air into a combustor 14. The combustor 14 also receives fuel for combustion from the fuel system 100, which conveys the fuel from a fuel tank 16, through a fuel line 102 and into the combustor 14 for combustion with compressor discharge air. The combustion products from the combustor 14 pass into the turbine 18, which extracts work from the combustion products to drive the compressor 12 and the balance of the power can be used in the case of a propulsive gas turbine engine to generate thrust, e.g. through an exhaust jet and/or by turning a fan, propeller, or other air mover.

[0013] With reference now to Fig. 2, the fuel control system 100 includes a first electric motor controlled fuel pump 104 having an outlet 106 operatively connected output pressurized fuel to the fuel line 102, and an inlet 108 configured to receive fuel supplied from the aircraft fuel tank 16. A second electric motor controlled fuel pump

110 has an outlet 112 operatively connected output pressurized fuel to the fuel line 102, and an inlet 114 configured to receive fuel supplied from the aircraft fuel tank 16. The first and second pumps 104, 110 connect in parallel with one another between the fuel tank 16 and the fuel line 102. This gives redundancy as well as power for high capacity when needed and low turn down capability. The pumps 104, 110 are each a high speed or multi-stage motor controlled fuel pump.

[0014] A plurality of fuel nozzles 116 are connected to the fuel line 102 to issue pressurized fuel from the fuel line 102 into the combustor 14. For sake of clarity in the drawings, only one fuel nozzle 116 is depicted in Fig. 2, however those skilled in the art recognize that a typical gas turbine engine has several fuel nozzles 116 each connected to issue fuel into the combustor 14. At least one of the fuel nozzles 116 includes a respective sensor system 118, and it can be advantageous for all of the fuel nozzles 116 to include respective sensor systems 118.

[0015] The sensor system 118 can include a pressure sensor 120 on an inlet portion of the respective fuel nozzle 116 that is configured to produce an input signal indicative of nozzle inlet pressure from the fuel line 102. The sensor system 118 can also include a pressure sensor 122 on an outlet portion of the respective nozzle 116 that is configured to produce an input signal indicative of nozzle outlet pressure. One or both of the sensors 120, 122 can include a temperature sensor, as indicated in Fig. 2 by T1, operatively connected to the respective nozzle 116 to produce an input signal indicative of nozzle inlet and/or outlet temperature. Any other suitable type of sensor can be used for detecting flow through the respective nozzle 116 and producing a signal indicative of nozzle fuel flow volume.

[0016] A fuel controller 124 is operatively connected to receive input from the respective sensor system or systems 118 of fuel nozzles. The fuel controller 124 is also operatively connected to control the first and second electric motor controlled pumps 104, 110 based on input from the respective sensor system or systems 118 of the fuel nozzle 116. Each of the fuel nozzles 116 includes internal valving operatively connected to the controller 124 so the controller 124 can control fuel flow through the plurality of fuel nozzles 116 by throttling the plurality of fuel nozzles, based on system needs, and by controlling the first and second electric motor controlled pumps 104, 110.

[0017] The fuel controller 124 can be a single controller which combines an engine controller 126 and a pump motor controller 128. The pump motor controller 128 can be operatively connected to receive input from an engine controller 126, and is configured to control the first and second electric motor controlled pumps 104, 110 based on input from the respective sensor system(s) 118, which can be interpreted by the engine controller 126. The engine controller 126 can be a full authority digital engine control (FADEC), and the pump motor controller 128 can be combined as part of the FADEC, or can be a separate unit connected to receive input from the FADEC for commanded pump speeds.

[0018] An engine heat exchanger 130 can be operatively connected to the fuel line 102 for heat exchange between fuel passing through the fuel line 102 and other engine fluids such as air, oil, coolants, and the like. The first and second fuel pumps 104, 110 are the only pumps in the fuel line 102 between the fuel tank 16 and the combustor 14. There need be no valves in the main line 102 from the first and second electric motor controlled fuel pumps 104, 110 to the plurality of fuel nozzles 116, since control of the fuel pumps 104, 110 and controlling the valving in the nozzles 116 alone are sufficient to maintain control of fuel flow.

[0019] A method of controlling fuel flow in a gas turbine engine includes pressurizing fuel from a fuel tank, e.g. fuel tank 16 by powering a pair of parallel electric motor controlled fuel pumps, e.g. pumps 104, 110. The method includes receiving input from a plurality of fuel nozzles, e.g. through sensor system(s) 118, which are supplied by the electric motor controlled fuel pumps, and controlling the electric motor controlled fuel pumps and valving in the nozzles with a closed loop feedback using the input from the plurality of fuel nozzles.

[0020] The systems and methods as described herein can potentially enable the following benefits among other potential benefits. The fuel pumping can be more efficient than in traditional systems due to elimination of the bypass line. There can be a reduction in the number of components in the fuel system relative to the traditional configurations. Systems and methods as disclosed herein can eliminate positive displacement pumping and valving of the traditional fuel systems. There can also be reduction of one pad from the gearbox relative to traditional systems since the fuel pumps 104, 110 are electrically powered. The can be an overall reduced system complexity, weight and cost, and the systems and methods as disclosed herein are better in alignment with the more-electric strategic vector of ongoing aircraft design than are the traditional fuel systems.

[0021] The methods and systems of the present disclosure, as described above and shown in the drawings, provide for fuel control for aircraft such as more electric aircraft. While the apparatus and methods of the subject disclosure have been shown and described with reference to preferred embodiments, those skilled in the art will readily appreciate that changes and/or modifications may be made thereto without departing from the scope of the invention as defined by the claims.

Claims

1. A fuel control system (100) for an aircraft comprising:

a first electric motor controlled fuel pump (104) having an outlet (106) operatively connected to output pressurized fuel to a fuel line (102), and an inlet (108) configured to receive fuel supplied from an aircraft fuel tank (16);

a second electric motor controlled fuel pump (110) having an outlet (112) operatively connected to output pressurized fuel to the fuel line (102), and an inlet (114) configured to receive fuel supplied from the aircraft fuel tank, wherein the first and second electric motor controlled fuel pumps connect in parallel with one another to the fuel line;

a plurality of fuel nozzles (116) connected to the fuel line to issue pressurized fuel from the fuel line, wherein at least one fuel nozzle in the plurality of fuel nozzles includes a respective sensor system (118); and

a fuel controller (124) operatively connected to receive input from the respective sensor system of the at least one fuel nozzle, and operatively connected to control the first and second electric motor controlled pumps based on input from the respective sensor system of the at least one fuel nozzle; wherein each of the fuel nozzles in the plurality of fuel nozzles (116) includes internal valving operatively connected to the controller (124) so the controller can control fuel flow through the plurality of fuel nozzles by throttling the plurality of fuel nozzles and by controlling the first and second electric motor controlled pumps (104, 110);

wherein the controller (124) is operatively connected to receive input from an engine controller (126), and is configured to control the first and second electric motor controlled pumps (104, 110) based on input from the respective sensor system (118) of the at least one fuel nozzle and from the engine controller; and

wherein the sensor system (118) of the at least one fuel nozzle (116) includes a pressure sensor (122) on an outlet portion of the respective nozzle and is configured to produce an input signal indicative of nozzle outlet pressure.

2. The system as recited in claim 1, wherein the engine controller (126) is a full authority digital engine control, FADEC.

3. The system as recited in claim 1, wherein the controller (124) comprises the engine controller (126), and wherein the engine controller (126) is a full authority digital engine control, FADEC.

4. The system as recited in any preceding claim, wherein the sensor system (118) of the at least one fuel nozzle includes a pressure sensor (120) on an inlet portion of the respective fuel nozzle (116) and is configured to produce an input signal indicative of nozzle inlet pressure from the fuel line (102).

5. The system as recited in any preceding claim, wherein the sensor system (118) of the at least one fuel nozzle (116) includes a temperature sensor operatively connected to the respective nozzle to produce an input signal indicative of nozzle inlet and/or outlet temperature.

6. The system as recited in any preceding claim, wherein the sensor system (118) of the at least one fuel nozzle (116) includes a flow sensor operatively connected to the respective nozzle to produce an input signal indicative of nozzle fuel flow volume.

7. The system as recited in any preceding claim, wherein each fuel nozzle in the plurality of fuel nozzles (116) includes a respective sensor system (118) operatively connected to provide input to the controller (124).

8. The system as recited in any preceding claim, further comprising an engine heat exchanger (130) operatively connected to the fuel line (102) for heat exchange with fuel passing through the fuel line.

9. The system as recited in any preceding claim, wherein the first and second electric motor controlled fuel pumps (104, 110) are the only pumps in the fuel line (102).

10. The system as recited in any preceding claim, wherein there are no valves in the main line from the first and second electric motor controlled fuel pumps (104, 110) to the plurality of fuel nozzles (116).

11. The system as recited in any preceding claim, wherein there is no bypass line bypassing flow through the fuel line (102).

12. A method of controlling fuel flow in a gas turbine engine using the fuel control system (100) of claim 1, comprising:

pressurizing fuel from a fuel tank by powering the first and second electric motor controlled fuel pumps;

receiving input from the plurality of fuel nozzles supplied by the electric motor controlled fuel pumps; and

controlling the electric motor controlled fuel pumps with a closed loop feedback using the input from the plurality of fuel nozzles.

13. The method as recited in claim 12, wherein controlling is performed by controlling valving in the plurality fuel nozzles.

Patentansprüche

1. Kraftstoffregelungssystem (100) für ein Flugzeug, umfassend:

   eine erste elektromotorgeregelte Kraftstoffpumpe (104) mit einem Auslass (106), der wirkverbunden ist, um unter Druck gesetzten Kraftstoff an eine Kraftstoffleitung (102) auszugeben, und einem Einlass (108), der dazu konfiguriert ist, von einem Flugzeugkraftstofftank (16) zugeführten Kraftstoff zu empfangen;
   eine zweite elektromotorgeregelte Kraftstoffpumpe (110) mit einen Auslass (112), der wirkverbunden ist, um unter Druck gesetzten Kraftstoff an die Kraftstoffleitung (102) auszugeben, und einem Einlass (114), der dazu konfiguriert ist, von dem Flugzeugkraftstofftank zugeführten Kraftstoff zu empfangen, wobei die erste und die zweite elektromotorgeregelte Kraftstoffpumpe parallel zueinander mit der Kraftstoffleitung verbunden sind;
   eine Vielzahl von Kraftstoffdüsen (116), die mit der Kraftstoffleitung verbunden sind, um unter Druck stehenden Kraftstoff von der Kraftstoffleitung abzugeben, wobei mindestens eine Kraftstoffdüse in der Vielzahl von Kraftstoffdüsen ein jeweiliges Sensorsystem (118) beinhaltet; und
   eine Kraftstoffregelung (124), die wirkverbunden ist, um Eingaben von dem jeweiligen Sensorsystem der mindestens einen Kraftstoffdüse zu empfangen, und die wirkverbunden ist, um die erste und die zweite elektromotorgeregelte Pumpe basierend auf Eingaben von dem jeweiligen Sensorsystem der mindestens einen Kraftstoffdüse zu regeln; wobei jede der Kraftstoffdüsen in der Vielzahl von Kraftstoffdüsen (116) eine interne Ventilanordnung beinhaltet, die mit der Regelung (124) wirkverbunden ist, sodass die Regelung den Kraftstofffluss durch die Vielzahl von Kraftstoffdüsen durch Drosseln der Vielzahl von Kraftstoffdüsen und durch Regeln der ersten und der zweiten elektromotorgeregelten Pumpe (104, 110) regeln kann;
   wobei die Regelung (124) wirkverbunden ist, um Eingaben von einer Triebwerksregelung (126) zu empfangen, und dazu konfiguriert ist, die erste und die zweite elektromotorgeregelte Pumpe (104, 110) basierend auf Eingaben von dem jeweiligen Sensorsystem (118) der mindestens einen Kraftstoffdüse und von der Triebwerksregelung zu regeln; und
   wobei das Sensorsystem (118) der mindestens einen Kraftstoffdüse (116) einen Drucksensor (122) an einem Auslassabschnitt der jeweiligen Düse beinhaltet und dazu konfiguriert ist, ein Eingabesignal zu erzeugen, das den Düsenauslassdruck angibt.

2. System nach Anspruch 1, wobei die Triebwerksregelung (126) eine vollautorisierte digitale Triebwerksregelung (FADEC) ist.

3. System nach Anspruch 1, wobei die Regelung (124) die Triebwerksregelung (126) umfasst, und wobei die Triebwerksregelung (126) eine vollautorisierte digitale Triebwerksregelung (FADEC) ist.

4. System nach einem der vorhergehenden Ansprüche, wobei das Sensorsystem (118) der mindestens einen Kraftstoffdüse einen Drucksensor (120) an einem Einlassabschnitt der jeweiligen Kraftstoffdüse (116) beinhaltet und dazu konfiguriert ist, ein Eingabesignal zu erzeugen, das den Düseneinlassdruck von der Kraftstoffleitung (102) angibt.

5. System nach einem der vorhergehenden Ansprüche, wobei das Sensorsystem (118) der mindestens einen Kraftstoffdüse (116) einen Temperatursensor beinhaltet, der mit der jeweiligen Düse wirkverbunden ist, um ein Eingabesignal zu erzeugen, das eine Düseneinlass- und/oder -auslasstemperatur angibt.

6. System nach einem der vorhergehenden Ansprüche, wobei das Sensorsystem (118) der mindestens einen Kraftstoffdüse (116) einen Flusssensor beinhaltet, der mit der jeweiligen Düse wirkverbunden ist, um ein Eingabesignal zu erzeugen, das eine Düsenkraftstoffflussmenge angibt.

7. System nach einem der vorhergehenden Ansprüche, wobei jede Kraftstoffdüse in der Vielzahl von Kraftstoffdüsen (116) ein jeweiliges Sensorsystem (118) beinhaltet, das wirkverbunden ist, um Eingaben an die Regelung (124) bereitzustellen.

8. System nach einem der vorhergehenden Ansprüche, ferner umfassend einen Triebwerkswärmetauscher (130), der mit der Kraftstoffleitung (102) wirkverbunden ist, um Wärme mit Kraftstoff zu tauschen, der durch die Kraftstoffleitung fließt.

9. System nach einem der vorhergehenden Ansprüche, wobei die erste und die zweite elektromotorgeregelte Kraftstoffpumpe (104, 110) die einzigen Pumpen in der Kraftstoffleitung (102) sind.

10. System nach einem der vorhergehenden Ansprüche, wobei keine Ventile in der Hauptleitung von der ersten und der zweiten elektromotorgeregelten Kraftstoffpumpe (104, 110) zu der Vielzahl von Kraftstoffdüsen (116) vorhanden sind.

11. System nach einem der vorhergehenden Ansprüche, wobei keine Umgehungsleitung vorhanden ist,

die den Fluss durch die Kraftstoffleitung (102) umgeht.

12. Verfahren zum Regeln des Kraftstoffflusses in einem Gasturbinentriebwerk unter Verwendung des Kraftstoffregelungssystems (100) nach Anspruch 1, umfassend:

Unterdrucksetzen von Kraftstoff aus einem Kraftstofftank durch Versorgen der ersten und der zweiten elektromotorgeregelten Kraftstoffpumpe mit Leistung;
Empfangen von Eingaben von der Vielzahl von Kraftstoffdüsen, die von den elektromotorgeregelten Kraftstoffpumpen versorgt wird; und
Regeln der elektromotorgeregelten Kraftstoffpumpen mit einer Rückkopplung in geschlossenem Regelkreis unter Verwendung der Eingaben von der Vielzahl von Kraftstoffdüsen.

13. Verfahren nach Anspruch 12, wobei das Regeln durch eine regelnde Ventilanordnung in der Vielzahl von Kraftstoffdüsen durchgeführt wird.

Revendications

1. Système de commande de carburant (100) pour un aéronef, comprenant :

une première pompe à carburant commandée par moteur électrique (104) présentant une sortie (106) reliée de manière opérationnelle pour délivrer du carburant sous pression à une conduite de carburant (102), et une entrée (108) configurée pour recevoir du carburant fourni depuis un réservoir de carburant d'aéronef (16) ;
une seconde pompe à carburant commandée par moteur électrique (110) présentant une sortie (112) reliée de manière opérationnelle pour délivrer du carburant sous pression à la conduite de carburant (102), et une entrée (114) configurée pour recevoir du carburant fourni depuis le réservoir de carburant d'aéronef, dans lequel les première et seconde pompes à carburant commandées par moteur électrique sont reliées en parallèle l'une à l'autre à la conduite de carburant ;
une pluralité de buses de carburant (116) reliées à la conduite de carburant pour délivrer du carburant sous pression à partir de la conduite de carburant, dans lequel au moins une buse de carburant dans la pluralité de buses de carburant comprend un système de capteur (118) respectif ; et
un dispositif de commande de carburant (124) relié de manière opérationnelle pour recevoir une entrée provenant du système de capteur respectif de la au moins une buse de carburant, et relié de manière opérationnelle pour commander les première et seconde pompes commandées par moteur électrique sur la base d'une entrée provenant du système de capteur respectif de la au moins une buse de carburant ;
dans lequel chacune des buses de carburant dans la pluralité de buses de carburant (116) comprend des vannes internes reliées de manière opérationnelle au dispositif de commande (124) de sorte que le dispositif de commande puisse commander le débit de carburant à travers la pluralité de buses de carburant en étranglant la pluralité de buses de carburant et en commandant les première et seconde pompes commandées par moteur électrique (104, 110) ;
dans lequel le dispositif de commande (124) est relié de manière opérationnelle pour recevoir une entrée provenant d'un dispositif de commande de moteur (126), et est configuré pour commander les première et seconde pompes commandées par moteur électrique (104, 110) sur la base d'une entrée provenant du système de capteur (118) respectif de la au moins une buse de carburant et du dispositif de commande de moteur ; et
dans lequel le système de capteur (118) de la au moins une buse de carburant (116) comprend un capteur de pression (122) sur une partie de sortie de la buse respective et est configuré pour produire un signal d'entrée indiquant la pression de sortie de la buse.

2. Système selon la revendication 1, dans lequel le dispositif de commande de moteur (126) est une commande de moteur numérique à pleine autorité, FADEC.

3. Système selon la revendication 1, dans lequel le dispositif de commande (124) comprend le dispositif de commande de moteur (126), et
dans lequel le dispositif de commande de moteur (126) est une commande de moteur numérique à pleine autorité, FADEC.

4. Système selon une quelconque revendication précédente, dans lequel le système de capteur (118) de la au moins une buse de carburant comprend un capteur de pression (120) sur une partie d'entrée de la buse de carburant (116) respective et est configuré pour produire un signal d'entrée indiquant la pression d'entrée de la buse à partir de la conduite de carburant (102).

5. Système selon une quelconque revendication précédente, dans lequel le système de capteur (118) de la au moins une buse de carburant (116) comprend un capteur de température relié de manière opérationnelle à la buse respective pour produire un signal d'entrée indiquant la température d'entrée et/ou de sortie de la buse.

6. Système selon une quelconque revendication précédente, dans lequel le système de capteur (118) de la au moins une buse de carburant (116) comprend un capteur de débit relié de manière opérationnelle à la buse respective pour produire un signal d'entrée indiquant le débit volumique de carburant de la buse.

7. Système selon une quelconque revendication précédente, dans lequel chaque buse de carburant dans la pluralité de buses de carburant (116) comprend un système de capteur (118) respectif relié de manière opérationnelle pour fournir une entrée au dispositif de commande (124).

8. Système selon une quelconque revendication précédente, comprenant également un échangeur de chaleur de moteur (130) relié de manière opérationnelle à la conduite de carburant (102) pour un échange de chaleur avec le carburant passant à travers la conduite de carburant.

9. Système selon une quelconque revendication précédente, dans lequel les première et seconde pompes à carburant commandées par moteur électrique (104, 110) sont les seules pompes dans la conduite de carburant (102).

10. Système selon une quelconque revendication précédente, dans lequel il n'y a pas de vannes dans la conduite principale allant des première et seconde pompes à carburant commandées par moteur électrique (104, 110) à la pluralité de buses de carburant (116) .

11. Système selon une quelconque revendication précédente, dans lequel il n'y a pas de conduite de dérivation dérivant le débit à travers la conduite de carburant (102).

12. Procédé de commande de débit de carburant dans un moteur à turbine à gaz utilisant le système de commande de carburant (100) selon la revendication 1, comprenant :

la mise sous pression du carburant provenant d'un réservoir de carburant en alimentant les première et seconde pompes à carburant commandées par moteur électrique ;
la réception d'une entrée provenant de la pluralité de buses de carburant alimentées par les pompes à carburant commandées par moteur électrique ; et
la commande des pompes à carburant commandées par moteur électrique avec une rétroaction à boucle fermée en utilisant l'entrée provenant de la pluralité de buses de carburant.

13. Procédé selon la revendication 12, dans lequel la commande est réalisée en commandant les vannes dans la pluralité de buses de carburant.

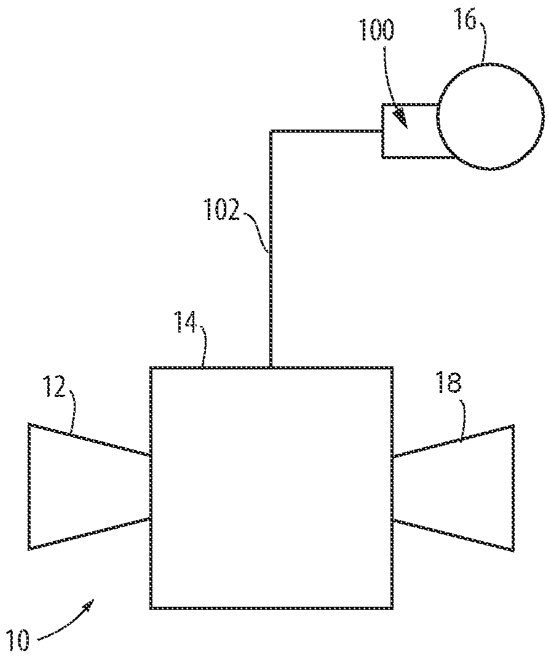
100
16
102
14
12
18
10

Fig. 1

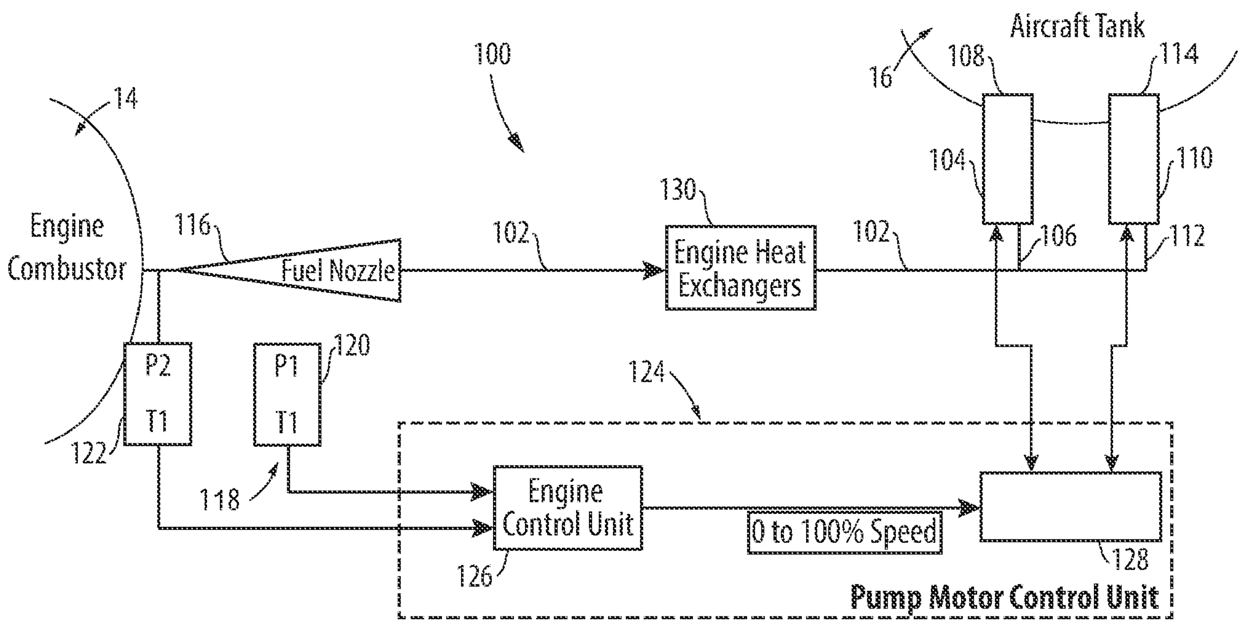
Aircraft Tank
16
108
114
100
14
104
110
Engine
Combustor
116
130
102
Fuel Nozzle
102
Engine Heat
Exchangers
106
112
P2
T1
P1
T1
120
124
122
118
Engine
Control Unit
0 to 100% Speed
126
128
Pump Motor Control Unit

Fig. 2

REFERENCES CITED IN THE DESCRIPTION

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